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Dr. Mary L. Cleave, Associate Administrator
Science Mission Directorate
NASA Headquarters
Washington, DC 20546

August 15, 2005

Dear Dr. Cleave:

The Planetary Protection Advisory Committee (PPAC) met during July 26-27, the first of such meetings at which I was privileged to serve as chair. Although the committee devoted a certain amount of the meeting time to advancing its understanding of emerging issues that will occupy its attention in the future, most of the focus was on questions related to forward contamination of Mars. At this meeting, the PPAC received its first information about the just-completed report of the National Research Council Space Studies Board, *Preventing the Forward Contamination of Mars*. The Committee benefited from the presentation and presence of Dr. Christopher Chyba, chair of the NRC COMMITTEE ON PREVENTING THE FORWARD CONTAMINATION OF MARS (PREVCOM).

While the *Preventing the Forward Contamination of Mars* report contains important and provocative analyses and recommendations – which resonate with issues that occupy the PPAC's attention – by the formal logic of the PREVCOM report as well as of necessity, the PPAC's current recommendations on forward contamination derive from NASA and COSPAR definitions and policies currently in effect. The Committee notes that the PREVCOM raised the question whether most or all regions on Mars ought to be considered "special regions" until specific data can be interpreted to indicate otherwise. In the absence of any policy revision by either NASA or COSPAR, and without prejudice to the possibility of future policy revision, the PPAC continues to work within currently existing and accepted policies.

The PREVCOM report and potential implications for NASA planning and programs will be taken up by the PPAC at subsequent meetings. The PPAC has not yet had opportunity to scrutinize the PREVCOM report in its entirety. Nonetheless, I believe it is fair to observe that NASA – owing to the ongoing work of the Planetary Protection Office and the prior work of this committee – will be in a position to develop and implement mission requirements needed to minimize risk of contaminating Mars in the next phases of Mars exploration, even as our growing understanding of that planet increases our appreciation of the likely existence of special regions that may present conditions favorable to the propagation of microbial life. However, it is also likely that robust application of strategies recommended by PREVCOM to support such requirements will require increased understanding of Earth-origin microbial contaminants and their potential effects on Mars. Looking ahead, it is reasonable to anticipate that gaining such increased understanding is likely to entail additional allocations of effort and resources.

The principal question requiring committee action at the July 26-27 meeting pertained to the Planetary Protection categorization of the Mars Science Laboratory (MSL) mission, which

according to current planning is expected to be launched to Mars in 2009. The committee benefited from the presence and participation of MSL project members and consultants as well as cognizant NASA Headquarters officials.

FOUNDATIONAL ISSUES

While deliberating on this subject, the PPAC was cognizant of several important factors that pertain to the Committee's purview and formal charge. Foremost amongst these is the fact that ascertaining the prevalence and nature of life in the universe constitutes one of the deepest motivations of the NASA mission, and responds to imperatives of the human intellect that have motivated speculation and analysis for thousands of years. Our generation enjoys the privilege of being able to address that question with a level of penetration heretofore unprecedented in human history. Most importantly for the NASA program, our generation is the first to directly explore other worlds and environments that are potentially sites of extraterrestrial life. If, in our explorations, we do indeed discover evidence of extant or prior life, answering the most important questions will require preserving the ability to ascertain the independence of such life from – or its relationship to – terrestrial life. Preserving that scientific ability is the primary motivation for avoiding forward biological contamination that might confound interpretations of biological independence or interrelationship.

In that respect, the prevention of confounding forward contamination of those sites that are serious candidates as sites for the origin of life, or hosts for the sustenance of life, is an imperative that is crucial to NASA's mission.

The Planetary Protection Advisory Committee takes note of two factors important in discharging its responsibilities:

- Planetary forward protection policies exist expressly for the purpose of enabling scientific investigations while guarding the likelihood that the results of such investigations will be of the highest feasible scientific integrity over the course of the period of biological exploration. In every instance when scientific investigation of a site of potential biological interest is contemplated, it is possible to make the case for delaying until more effective protective protocols may be possible or affordable, or until more information may be available on which to base precautionary measures. Nonetheless, the PPAC recognizes that facilitating science is a high imperative, and that, while planetary protection is a foremost consideration, there are no zero-risk scenarios other than inaction, which itself is unacceptable. Each judgment balances the reality of non-zero risk of contamination with scientific value of investigation.
- Evaluating the risk of forward contamination is made difficult by the paucity of certain experimental data. As an example, though not a unique example, projects continue to rely on assessments of the "probability of growth" of terrestrial microbes or spores emplaced in extraterrestrial environments (P_G). The empirical basis for estimating P_G is sparse and limited in the range of experiments that have thus far been carried out and reported. Although the Committee has no specific reason to believe that P_G is substantially higher than assumed in, for example, the Mars Surface Laboratory project's analysis, there is room for debate on the matter. This weakens forward contamination abatement plans that rely on probability of growth estimates.

  This matter is raised here for two reasons. Firstly, the PPAC did not find arguments based on probability of growth – as put forward by the MSL Project – persuasive as a sufficient basis for shaping an MSL planetary protection plan. This conclusion should not be construed as a criticism of the MSL project team's analysis, but rather as an observation on the state of the

art. Secondly, this matter is raised to call attention to the need for further research – and for the investments to underwrite that research – to better define parameters crucial to planning for control of forward contamination risks. This is a matter to which the committee will return in the future, and it is a matter raised in the NRC report on *Preventing the Forward Contamination of Mars*.

MARS SCIENCE LABORATORY PLANETARY PROTECTION REQUIREMENTS

The Planetary Protection Advisory Committee recommends that the Mars Science Laboratory project fulfill its forward planetary protection responsibility by following either one of the following two approaches:

1. Apply the protocol employed for the Viking Project by implementing controlled cleaning and assembly followed by a system-level dry heat microbial reduction (DHMR) in accordance with Category IVc restrictions, and preserving the lander's state of cleanliness through delivery to the surface of Mars.
    - Under this option, no further restriction on landing sites is required within the envelope of landing-site definition proposed in the MSL mission design presented to the PPAC and the project's Planetary Protection "white paper".

OR

2. The landing system and rover be cleaned to the Viking-standard pre-sterilization-level of bioburden (i.e., Category IVa), with the further requirement that hardware contacting the Martian subsurface (i.e., beyond the depth disturbed by the rover in the course of its movement) be cleaned to the Viking post-sterilization-level of bioburden. Collectively these requirements are construed as comprising a Category IVc implementation for the purposes of this mission.
    - Under this option, no landing or roving into a surface *special region* is to be permitted. The term *special region* is taken here to conform with the definition set forth by the COSPAR guidelines in force at the time this letter is written.
    - Under this option, vertical access into subsurface regions is to be permitted only by the sterilized hardware components.
    - Under this option, if a Radiothermal Power Source (RPS) is incorporated into the lander system, the landing-site target shall be selected so as to satisfy the requirement that failure modes during entry that leave the RPS intact and in contact or in close proximity with unsterilized lander components shall not result in potential off-nominal landing ellipses falling in or overlapping regions where there is evidence of extant water or ice within 1 meter of the surface. (This provision shall not be construed as requiring that the sites be devoid of bound water of hydration.)
    - Under this option, landing-site acceptability (including off-nominal-event impact site acceptability) shall be reviewed and assessed for planetary protection acceptability in light of the most up-to-date data and models available at the time of landing-site selection prior to launch.

Insofar as one anticipates a nominal mission with successful entry into the Martian atmosphere, and landing and deployment on the surface, the mission profile is acceptable from a planetary protection

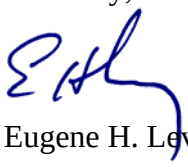
perspective, so long as the surface operations adhere to the requirements set out herein. The principal difficult-to-control planetary protection risks are those associated with failure to successfully land. The most important risks involve the possibility that the lander system suffers an uncontrolled impact with the surface under conditions that can create a localized warm and wet zone in which terrestrial organisms carried to Mars with the system could survive and multiply. Thus concern focuses especially on failure scenarios that could implant both contaminated spacecraft or lander components and the Radiothermal Power System – or components of it – in such a way as to result in a warm wet zone encompassing the contaminated components, and in which the implanted organisms or spores could subsequently grow and migrate away from the site. Even in the event of such an occurrence, however, if the locally produced contamination were to be contained against spreading of live or viable organisms, the consequences, while undesirable, would fall within acceptable limits. The Martian surface environment – especially by virtue of the ultraviolet radiation flux – is thought to present a difficult barrier to the spread of viable organisms, though arguments can be made that such spread is not impossible. All of these considerations were factors in assessing the acceptability of forward contamination risks associated with the Mars Science Laboratory mission.

Lastly, we note that the PPAC recommendations on MSL planetary protection measures attempt to balance factors alluded to earlier in this letter. In addition, the Committee was mindful of the need to define requirements in such a way as to be verifiable. Ideally, given uncertainties cited earlier, such as about probability of growth, arguments could be – and were – made for setting a more stringent requirement on the absence of water and ice from potential entry-failure impact ellipses, down to a level of two meters or more. However, the limitations on the availability of data to reliably verify that such stringent requirements are met could place such a heavy burden on the scientific flexibility of the mission – with respect to landing sites and operations – as to compromise the scientific objectives to an extent greater than justified by the uncertainties. However, we note that this inability to verify the absence of water to greater depth does increase the attendant risks.

In closing, I want to acknowledge the Planetary Protection Office and Dr. John Rummel for the consistently facilitative environment within which the PPAC functions. I also want to acknowledge the time, effort and focused attention of the members of the PPAC in discharging the responsibilities of the Committee. I would be happy to respond to any questions or try to clarify any issues that arise out of the Committee's deliberations or this letter.

With warm regards,

Sincerely,



Eugene H. Levy, Chair
Planetary Protection Advisory Committee

cc: John D. Rummel, Planetary Protection Office
Members of the Planetary Protection Advisory Committee
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